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ABSTRACT

The Golden Section as a concept and a term has had a long history in the arts as well as the sciences. It is one of those concepts that has undergone much recent research, which is presented as part of this review. The research is considered in relation to the design fields and to the creation of visual forms rather than aesthetic preference studies. This review of the Golden Section is limited to psychological rather than philosophical studies. A basic assumption in this and other studies is that the study of aesthetic preference has a prior relationship to decision making in design, art, and art education. The material is reviewed in terms of the current interest in symmetry theory in both the arts and sciences. The evolution of chaos theory and the new science of chaos makes the studies that this paper reviews all the more relevant. (Author/SG)

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A Review of Research on the Golden Section Hypothesis in Art and Design

by

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Abstract

"The Golden Section" as a concept and a term has had a long history in the arts as well as the sciences. It is one of those concepts which has undergone much recent research which will be presented as part of this review. The research will be considered in relation to the design fields and to the creation of visual forms rather than aesthetic preference studies. This review of the Golden Section shall be limited to psychological rather then philosophical studies. A basic assumption in this and other studies of the author is that the study of aesthetic preference has a prior relationship to decision making in design, art, and art education.

The material will be reviewed in terms of the current interest in symmetry theory in both the arts and sciences. The evolution of chaos theory and the new science of chaos makes the studies reviewed in this paper all the more relevent.

Introduction

Psychological Research in Art, Design and Art Education has long been concerned with the measurement of aesthetic preference and aesthetic judgment. The attempts at doing this research within the general framework and methodology of experimental psychology has not, in this writer's judgment, been productive. (McWhinnie, 1965) We have reviewed a series of studies in aesthetic measure which demonstrated that children's visual preferences when compared to those of artists was neither predicatable nor reliable. In a second review of this literature, this writer (McWhinnie, 1970), demonstrated that the practice of using professional artists as a normative group measured aesthetic preference as determined by current artistic trends and tastes but could not become a general basis for the assessment of aesthetic preference.

A more predictable and reliable method for studying aesthetic preference in the responses of adults as well as children may be found in the research literature on the Golden Section. The basic hypothesis behind the Golden Section is that it might be a natural or organic approach to visual as well as natural forms.

The history of the Golden Section is one of those central constraints which undergirds all of life and gives us some degree of expectation that as a ratio it can be highly predictive of growth in many forms. As a concept, it seemed to this

writer highly worthwhile to reconsider it in reference to the general psychological problem of the assessment of aesthetic preferences. (McWhinnie, 1987)

Much of the research to be reviewed in this paper comes from psychological studies that were concerned with social and interpersonal judgment. These studies have been selected for a review instead of studies from aesthetic preference in order to give a new and we hope a different perspective to this general question.

Work of Benjafield:

Another writer (Benjafield, 1978), has reviewed the conception of the Golden Section in relation to studies of human behavior in art. He wrote "Considered as a whole, the studies have quite an elegant, self-regulating structure". The studies constitute an example of such a structure in that the movement from tension to relief, or from internal contradiction to internal consistency, is achieved while still conserving the Golden Section. The Golden Section can be seen as a norm that determines which transformations are in fact permissible. Negative features may be changed into positive ones, and vice-versa, but these changes must compensate for each other so as to preserve the overall balance between the positive and the negative. This balance is represented by the Golden Section. The Golden Section is a proportional movement which relates to both human behaviors as well as to visual forms.

The concept of the Golden Section as a norm that determines how much change or deviation is permitted or made acceptable has, it seemed to us, wide applications for art and design decisions. While a mathematical ratio, the golden section as a concept is of a far widder origin. This idea of Benjafield would seem to be one of those basic conceptions which can be generative of much good research. This concept has not been properly identified in art and design research. Let us now see how he developed this important observation.

In reaching this conclusion, we are making a point that is consistent with

observations made by other theorists about the Golden Section. As Thompson has suggested, the Golden Section can be seen as a symbol of harmony between opposing forces that involves neither an excess, nor a defect, of either one. Still, we must ask, why is this proportion, and not some other, the ideal proportion in these situations? (Thompson, 1917)

The answer to this question may be found by implication in the aforementioned studies of interpersonal judgment. Although the characters and situations depicted in fairy tales are often unrealistic, in the sense of being unlikely to be encountered in everyday life; the connotative structure of the characters is much like that found in our interpersonal environments. Since the stories are, in part, vehicles for teaching children about the general features of human nature, this correspondence makes perfectly good sense. We suggested previously that the Golden Section might be a figure-ground relation which tends to make negative events figure against a positive background. It follows then, that these stories tend to draw the spectator's attention to the negative, to what is problematic in life, and demonstrate to the child that, while individuals may change; the balance between the positive and the negative endures. That balance in the ratio of the golden section or 1.61813, the value of PHI .

In conclusion, this analysis provides additional support for the claim that the Golden Section is an important part of aesthetic structure. In our view, the discovery of Golden Section relationships in these stories has two important theoretical consequences. First, it shows that elegance and precision can be a part of stories generated in an informal and untutored way. Second, we are able to see a new connection between very different forms of creative enterprise.

Benjafield's general point of view is an extension of Berlyne's work (Berlyne, 1971). Berlyne was one of the first major researchers to argue that is was a mistake to base psychological research into aesthetic preference upon the

preferences of artists. His attempts to do what he called "Aesthetics from Below" began an important series of experiments on preference and judgment for abstract Gestalt - like forms. In essence what Berlyne did was more the study of aesthetic preference away from social psychology and personality theory to cognitive psychology. Such a shift in focus was a major step forward.

If Behavioral Science research acquires a new dignity when seen to possess a Golden Section structure, then it is also true that the use of the Golden Section in other milieus, such as painting and architecture, might take on a less esoteric appearance. The aesthetic appeal of the Golden Section need not be justified by using arcane mathematical principles. On the contrary, it may be that those who consciously employ the Golden Section are making explicit an organizational principle which unconsciously informs many of those distinctions we ordinarily make. An architect using the Golden Section to divide a line is behaving in a way that is analogous to any one using the Golden Section to divide our acquaintances into those we regard positively and those we regard negatively.

Le Corbusier insisted that the Golden Section was not just a mathematical curiosity, but one that fit the proportions of the human body. Our view is complementary to Le Corbusier's. We believe that the Golden Section fits the way we normally make distinctions. Consequently, we should not be surprised if it turns our that the Golden Section regulates the connotations of literary works which have a universal appeal.

It may surprise some people to find that the name "golden section," or, more precisely, "goldener schnitt", (the division of a line AB at a point C such that $AB * CB = AC^2$), seems to appear in print for the first time in 1835 in the book Die Reine Elementar-Mathematik by Martin Ohm, the younger brother of the physicist Georg Simon Ohm. By 1849, it had reached the title of a book Der Allgemeine Goldene Schnitt und Sein Zusammenhang mit der Harminischen Theilung by A.

Wiegang. The first use in English appears to have been in the ninth edition of the Encyclopaedia Britannica (1875), in an article on Aesthetics by James Sully in which he refers to the "interesting experimental enquiry ... instituted by Fechner into the alleged superiority of 'the golden section' as a visible proportion. Zeising, the author of this theory, asserts the most pleasing division of a line, say in a cross, is the golden section ..." The first English use in a purely mathematical context appears to be in G. Chrystal's Introduction to Algebra (1898). (Fouler, 1982, pp. 146)

We undertook this particular research into the Golden Section hypothesis as a part of a larger project which involved the life and work of the American artist and designer Jay Hambidge. Hambidge's use of dynamic symmetry was an important part of early design theory in this country and involved the golden section as the basic principle. (Hambidge, 1924). The development of modern design theories in recent years which have a behavioral basis, make more relevent the range of studies done in the past 25 years, that have applied the Golden Section as a general hypothesis to a wide range of studies in various disciplines.

The mathematical theory of the golden section can be found in many places. We would cite Chapter 11 of H.S.M. Coxeter's Introduction to Geometry as both the best and most accessible reference, and further developments can be found in other of Coxeter's works (Coxeter, 1900). The briefest acquaintance with any treatment of the Fibonacci series will indicate why many accounts of that topic will tend to the golden section, and The Fibonacci Quarterly is a rich source of articles and references on this subject. That there appears to be a connection between the Fibonacci numbers (and hence the golden section) and phyllotaxis (i.e., the arrangement of leaves on a stem, scales on a pine cone, florets on a sunflower, infloresences on a cauliflower, etc.) is an old and tantalizing observation. The subject is introduced in Coxeter, a brief historical survey is included in a

comprehensive paper by Adler, and Coxeter give a short and authoritative statement.

The application of the golden section to other fields has, however, created a vast and generally romantic or unreliable literature. For instance, the application to aesthetics is, by its nature, subjective and controversial; and a good brief survey with references is given in Wittkower. For a comprehensive example of the genre, see the rival explanation and critical view of the role of the golden section in literature, art, and architecture in Brunes, The Secrets of Ancient Geometry (Brunes, 1921). Lest we be incorrectly understood to be dismissing the scientific and experimental study of aesthetics as worthless, let us cite H.L.F. von Helmholtz's "On the Sensations of Tone" as an impressively successful example of this type of investigation, that was at the very basis of science, mathematics, scholarship, and sensibility. This book contains the first explanation of the ancient Greek observation that harmony seems to be connected with small integral ratios. But it is precisely Helmholtz's masterly blend of acoustics, physiology, physics, and mathematics that establishes firmly a standard which so few other writers on scientific aesthetic have reached.

With this outline of the recent history of the golden section behind us, our objective here is to treat the construction as it is described in Euclid's Elements under the name of "the line divided in extreme and mean ration" and to develop and explore beyond the propositions we find proved there. Our purpose is historical: it is to propose implicitly the question of whether the general characterizations to be described here might have had any part, in the development of early Greek mathematics. Let us isolate this discussion of the ancient period from the later convoluted ramifications sketched in this introduction. We would like to finish with what is, we hope, an accurate description of the surviving evidence about the Greek period: the propositions to be found in Euclid's Elements consititute the only

direct, explicit, and unambiguous references to the construction in early Greek mathematics, philosophy and literature. The only other surviving Greek references are to be found in mathematical contexts, in Ptolemy's Syntaxis, Pappus' Collection, Hypsocles "Book XIV" of the Elements, and an anonymous scholar on Book II of the Elements. (Fouley, 1982, pp. 147-48)

Fouley's research is important because it has clearly identified some of the classic sources for our conception of the golden section. He continued to define the basic conception of the golden section and concluded with a review of some of those studies that are basic to the body of research under review in this paper.

The Definition of Euclid's Elements

The golden ratio is defined at the beginning of Book VI of the Elements:

> **A STRAIGHT LINE IS SAID TO HAVE BEEN CUT IN EXTREME AND MEAN RATIO WHEN, AS THE WHOLE LINE IS TO THE GREATER SEGMENT, SO IS THE GREATER TO THE LESS.**

The Golden Section (GS) is the proportion obtaining between two quantities A and B when A/B = B/(A+B) - .62. This proportion appears in a variety of contexts. For example, many plants have leaves that spiral about the stem such that the number of turns of the spiral divided by the number of leaves equals the golden section (Mitchison, 1977). The Golden Section also appears to be of some significance in aesthetics. Many artists have claimed that it is a more pleasing proportion than any other, and have often used it to organize their work (Arnheim, 1954). The so-called Golden Rectangle has its sides in this proportion, and Fechner (1876) provided experimental evidence that people find this rectangle more aesthetically pleasing than any other. While Fechner's findings have long been a source of controversy (Zusne, 1970), recent experiments suggest that people may, in fact, have a tendency to prefer the Golden Section (Benjafield, 1976; Piehl,

1978; Svensson, 1977)).

The possiblity that the golden section informs our aesthetic judgments is intriguing since the GS played such an ubiquitous role in mathematics, science, and art (Huntley, 1970). In fact, the GS appears to occur in other forms of human judgment as well. For example, Benjafield and Adams-Webber (1976) found that when subjects are asked to divide a set of their acquaintances into a positive class (P) and a negative class (N), the resulting proportion tends to be the GS, that is, P/(P+N) .62. This finding has been replicated several times (Adams-Webber, 1978; Benjafield and Green, 1978; Benjafield and Pomeroy, 1978), and is consistent with the hypothesis, advanced by Benjafield and Adams-Webber (1976), that in a variety of contexts in which people divide events into two classes they tend to make this division unequally in a proportion that approximates the GS.

In a consideration of Benjafield's results it has been suggested that the GS is an ideal (Benjafield and Pomeroy, 1978), (Bregman's 1977) may be demonstrated in a variety of ways. Similarly, current evidence suggests that the GS is instantiated in a variety of contexts, from the aesthetic to the interpersonal. The more practised one becomes with imitating an ideal, the more accurately will the imitation match the underlying ideal. The accuracy with which the GS is imitated may reflect the frequency with which it is used. The fact that it appears to be imitated with a high degree of accuracy implies that it may be at least a basic a way of dividing into two equal parts. As to why the GS is used so frequently, recent explanations include the following: (1) the GS affords maximal contrast between figure (the minor portion) and ground (the major portion) (Berlyne, 1971, p. 232); (2) when events are organized in the GS, as opposed to other ratios, they are less susceptible to distortion when regarded from different perspectives (Fischer, 1969); and (3) the GS reflects a basic mode of functioning of the brain since the latencies of cortical-evoked potentials seem to be organized in this ratio (Shafer,

1974). Given that the psychological reality of the GS is reasonably well established, it is time to turn our attention towards establishing whether any of these explanations for its occurrence are correct, or whether or not a new explanation is required.

We will now consider research that lies outside of the general Berlyne - Benjafield tradition. We will turn to some of the evidence from the arts themselves. We should keep in mind that the GS is a means for iniating the ideal and by the continued practice over the generations since fifth century Athens, it's usage has become highly intuitive. It may now function quite subconsciously as an organizing principle within the arts.

Evidence from the Arts

A note from the Journal of Aesthetic and Art Criticism (Benjafield and Davis, 1978) review some of the more notable instances of the Golden Section hypothesis as it has been used in a variety of art forms. One of the most striking appearances of the Golden Section is in Bartok's music. Lendvai has conclusively demonstrated that Bartok used it as a regulating principle. "As an example, let us take the first movement of the Sonata for Two Pianos and Percussion. The movement comprises 443 bars, so its G(olden) S(ection) ... is 443 x 0.618, i.e., 274, which indicates the center of gravity of the movement; the recapitulation starts precisely at the 274th bar." Lendvai gives numerous examples of this sort which leave no doubt of the involvement of the Golden Section in Bartok's work (Benjafield & Davis, 1978).

Why does the Golden Section appeal to many artists? One reason might be its' frequent occurrence in nature, specifically in some living forms. Structures as diverse as sunflowers and nautilus shells are organized in Golden Section proportions. Thus, the artist who wishes to use a "natural" proportion in his work

will find the Golden Section appealing. In Bartok's case, the use of the Golden Section was probably linked to Bartok's desire to represent basic, living structures in his music and it led him to the Golden Section on the one hand, and folk music on the other. It is our belief that the link between the Golden Section and folk art is not merely a fortuitous connection, but the Golden Section is an important regulating principle in at least some forms of folk art.

The possiblity of such a link is suggested by the evidence that the Golden Section is a preferred proportion even for those without any special aesthetic training. Fechner was the first to provide evidence for the existence of such a preference. Although Fechner's findings have long been a source of controversy, Benjafield's data suggests that the Golden Section may indeed be preferred over proportions which deviate markedly from it. Moreover, since Benjafield and Adams-Webber found a tendency for people to use the Golden Section in interpersonal judgment as well; these studies might provide a rationale for reviving the notion that the Golden Section is a "normal" preference, and not simply an acquired taste.

Recently, however, Godkewitsch (1974) argued that these previous findings are artifacts of the 'stimulus range' and the measure of preference used. He presented data indicating that preference is a function of the range of rectangles from which the subject is asked to choose. In his experiment, subjects tended to make their initial choices at the extremes of these stimulus ranges with which they were presented, and thus no particular rectangle was preferred, in absolute terms, over any other.

Godkewitsch's (1974) findings are difficult to interpret because, unlike Fechner (1876) and others reviewed by Zusne (1970); he did not control for the size of the rectangles in the ranges presented to subjects. The rectangles varied from 25 sq cm to 66 sq cm in area, the smallest being a square, and became larger as the

ratio of larger to smaller side increased. Thus, size and proportion were completely confounded, and there is no way of knowing on which of the two subjects based their judgments. One purpose of the present study was to test the hypothesis that when a control for size is introduced, preference for rectangles near the golden section. (McWhinnie, 1985)

An additional focus of this study was on the measure of preference. This has not always been suited to the object of investigation. Many investigators, including Godkewitsch (1974), have subjects make their first choice at the outset of the experiment and then make successive choices. This is a bit like asking a person who has just entered an unfamiliar art gallery to immediately select his favorite painting. From the point of view of many congnitive theories (e.g., Flavell and Draguns, 1957; Neisser, 1967), judgment is the outcome of a process that develops over time, being at first global and gradually becoming more differentiated and precise. It would be useful to have a scale of preference that reflects this process and takes into account global preferences as well as more articulate preferences for specific rectangles. Consequently, a method for eliciting preferences was derived from Kelly's (1955) repertrory-grid technique, a method which not only allows the subject to gradually articulate his judgment but also yields such a scale. (Benjafield, 1976, pp. 738-39).

The results for the two series were strikingly different and are described in turn. The total preference score is the sum of the individual scores for 30 subjects and thus has a maximum possible of 90. In a nonparametric trend analysis of the data (Ferguson, 1965) revealed significant monotonic trends for the small range (polygons) and for the middle range (polygons), but not for the large range. None of the bitonic trends was significant.

These findings suggest that subjects will, in general prefer 'large' to small rectangles, unless the rectangles in the range the subjects are given are all

relatively large in relation to the background. The subjects' spontaneous comments bore out this interpretation, the most frequently occurring statement being "I like the large ones." This finding is not surprising in view of the positive connotations of the word 'large' and the negative connotations of 'small' (Osgood and Richards, 1973). Rectangles subjects describe, whether covertly or overtly, as large will thus be reacted to more positively than those they describe as small.

These results are quite different from Godkewitsch's (1974) finding that subjects preferred the extremes of ranges. Obviously, the difference between the two studies lies in the measure of preference used. Forcing subjects to make first choices at the outset probably makes them attend to the ends of the distribution of alternatives, an analogue of the familiar serial-position effect in verbal learning. The present study indicates that when subjects are allowed to articulate their judgments more slowly, then a fairly clear tendency to prefer large over small rectangles emerges. This suggests further that for this series, the cue on which subjects base their judgment is size, and not proportion. Thus, the question of whether or not the golden section is a preferred proportion cannot be settled with data from an increasing-size series.

Work of Adams-Webber

The work of Adams-Webber applies the Golden Section Hypothesis to studies of interpersonal judgments. Here we are not looking at judgments of visual forms in terms of shapes, areas, lines, etc. that could be clearly based on Euclid. Instead in these studies we look at the data in terms of ratios which also appreciate the Golden Mean. These studies of Adams-Webber extend the idea of the Golden Section too far more then visual forms.

This study examined the effects of role-playing constrasting positive and negative moods on the way in which people construe themselves and others. Undergraduates completed a base-line repertory grid in which they categorized

themselves and acquaintances on bipolar constructs, e.g., "excitable/calm". As in previous studies, they assigned others to the "unlikeself" poles of constructs approximately 37% of the time, and to the positive poles about 63% of the time. They twice repeated this grid while role-playing positive and negative moods. In the negative-mood grid, they characterized both themselves and others more negatively, and construed others as less similar to themselves. In the positive-mood grid, they evaluated themselves and others more positively, and described others as more similar to themselves.

A general assumption of personal construct theory, which has been implemented in Kelly's fixed-role therapy, is that role playing can lead to changes in people's view of both themselves and others. Specifically, Benjafield and Adams-Webber (1975) found that in role playing a shift in current self-image from "typical self" to "ideal self" produced a significant increase in the proportion of like-self judgments in repertory grids. The research reported here is concerned with the effects of role playing, temporary changes in mood, both positive and negative, on the ratio of construed similarities and differences between self and others. Specifically, participants completed repertory grids while successively role playing reactions to pleasant and unpleasant personal experiences.

Adams-Webber and Davidson (1979) began to draw upon and identify with Berlyne's work at their formation level for so much of the interpersonal based research into the Golden Section. Frank, as summarized by Berlyne (1972), operationally defines the 'strikingness' (salience) of an event in terms of its' relative frequency of occurrence (Pi), and the amount of 'information' it contains ($\log_2 1/Pi$). His index is the product of these two value: $Pi \log_2 1/Pi$. Berlyne (1972, p. 231) indicates that $Pi \log_2 1/Pi$ reaches its maximum value when $Pi = 1/e$, which is approximately 0 x 368. In a reanalysis of data from several 'repertory grid' (Kelly, 1955) experiments in which subjects categorized themselves and others

in terms of bipolar dimensions; e.g. calm-excitable; the data revealed that they tended to assign others to different poles than the 'self' approximately 37 percent of the time (Benjafield & Adams-Webber, 1975; Adams-Webber & Benjafield, 1976; Benjafield et al., 1976; Adams-Webber, 1977, 1978a).

Adams-Webber (1977, 1978a) suggests, in the light of Frank's hypothesis, that this particular distribution of 'like-self' versus 'unlike-self' judgments allows perceived differences between the self and other to stand out maximally as 'figure' against a diffuse "background" of similarities. This could prove to be an important factor in the organization of personal judgments; however, we have only examined this relationship with data from previous research employing relatively small samples of undergraduates and other young adults. The purpose of his experiment was to replicate this finding with original data based on a fairly large sample which included both university students and subjects who were appreciably younger and somewhat more representative of the general population.

Work of Godkewitsch

Three sets of variables seem to contribute to the appreciation of humour stimuli (Godkewitsch, Note 1, 1974) which are as follows: First, characteristics of the receiver such as his personal problem areas, intelligence, sex, and developmental stage seem to affect humour responses. Secondly, the social context of the humour stimulus provides the second group of variables. For instance, a comedian leads his audience to expect something funny rather than something tragic. Thirdly, stimulus properties can determine the intensity of humour responses. The present study concentrates on the impact of the third set of variables on the enjoyment of jokes.

The thematic and collative properties of jokes represent two kinds of basic stimulus properties. Thematic properties have to do with the subject matter: jokes are often distinguished into tendency jokes, whose contents are formed by

affective themes such as sex and overt aggression, and non-tendency jokes, such as clever jokes, puns, and riddles that motivate problem solving activity. Experimental evidence confirms the importance of themes for funniness evaluation. Godkewitsch (1974), for instance, showed that the perceived amount of sex in sex jokes varied positively with scaled funniness. His results showed that: (1) First, funniness ratings for all jokes were averaged across subjects. Mean funniness of the sex jokes varied from 3.2 to 5.2 on the seven-point rating scale; while the funniness of the verbal put-ons varied between 3.1 and 4.5. Harmless wit was less appreciated: mean funniness varied from 1.9 to 3.9. The variance among the three groups of jokes were 1.7, 1.6 and 1.7 respectively. Next, ratings on the seven other rating scales were similarly averaged. The reliabilities of the average ratings were all over .70 (except for the APPROPRIATE scale) and thus satisfactory. The eight rating scales were correlated with the mean rated funniness levels for each of the three theme groups of jokes separately (2) The rated funniness of sex jokes was positively and significantly correlated with the predicatablity, expectedness, and appropriateness of the punchlines, and negatively with their surprisingness, which supported the first hypothesis. For harmless wit no significant relations were found, but the funniness of verbal put-ons was positively related with the appropriateness of the punchlines, and negatively with the perceived likelihood and usualness of the situation as described in the joke body. The same relations were found for the combined group of 20 non-tendency jokes. These findings supported the second hypothesis. Finally, the correlations between funniness and the rated predictability, expectedness, and surprisingness of the punchlines for sex jokes were significantly different from thos for harmless wit and from those for the combined group of non-tendency jokes. Such results providing some support for the hypothesis that these relations may be quite dissimilar for tendency and non-tendency jokes.

The 'golden section' is a particular ratio between two independent stimulus parameters, most often two indexes of size of a visual display. When this ratio, defined by the equation $A/B = B/(A + B)$, prevails between the length and width of an architectural creation, it has been claimed (Ghyka, 1931; Borissavlievitch, 1952; Le Corbusier, 1954) to elicit more pleasure than any other ratio. In visual perception, the golden section purportedly embodies properties that lie at the root of the hedonic value of the given stimulus. Numerous authors have presented anecdotal evidence and incidental observations causally linking the golden-section ratio and subsequent positive affect (see Berlyne, 1971).

There is, however, no agreement about the cause of preferences for the golden section. According to Kulpe (1893), this ratio is a special case of the constancy of the differential limen: the sides of a rectangle are just different enough to be comfortably discriminable, but sufficiently equal to create a unified impression. Borssavlievitch (1952), Stone and Collins (1965), and Schiffman (1966) propose that the golden section is best liked because it corresponds to the ratio between the dimensions of the binocular visual field. Berlyne (1971) discounts these theories and states (Berlyne, 1970) that the data from the dozen or so studies over the last hundred years are "suggestive, but not conclusive." Admitting that preferences of Western subjects do indeed center in the vicinity of the golden section, Berlyne (1970) shows that it does not seem to be as outstanding in that vicinity as was claimed by earlier investigators. From his cross-cultural research, indicating that Japanese subjects prefer a more equal ratio (i.e., rectangles more closely approximating the square), Berlyne concludes that preferences for ratios around the golden section are due to cultural tradition.

An alternative explanation of preferential ratings for the golden section may be related to characteristics of the stimulus array in which the golden section is embedded. Typically, subjects have been presented a set of rectangles in which the

golden section was located near or at the midpoint of the range of length/width ratios. This becomes apparent when the data presented in Table 1 are considered.

INSERT TABLE ONE

In the eight published experiments in which rectangles were the stimuli, a total of 72 rectangles more closely approximated the square, and 77 rectangles were more elongated than the golden section. Except for the studies by Fechner and by Lalo, the highest mean preferences in Table 1 were obtained by have subjects respond to all successive stimuli in the set and then averaging these responses -- in all cases, forms of preference rankings. Thus, while mean preferences centered at or near the golden section, they were simultaneously located at the middle of the range.

Fechner (1876), followed by Lalo (1908), reported rather the first choices of his subjects. In Fechner's study, the subjects, asked to choose the most pleasing rectangle, often waited and wavered, rejecting one rectangle after another. Meanwhile, the experimenter would explain that they should carefully pick a rectangle whose ratio between its sides could on the average be considered as most satisfying, harmonic, and elegant (Fechner, 1876, p. 195). The demanding characteristics of the experimental situation may have forced the subjects to minimize their discomfort by choosing the middle of the range: the golden section. In short, it may be argued that the effect of length/width ratio as a stimulus-intrinsic property and the effect of range characteristics are confounded in the mean preference data from the eight studies.

It can therefore be hypothesized that preference for any length/width ratio of a rectangle, and thus for the golden section, is an artifact of the stimulus range: within any range of length/width ratios of rectangles, the mean preference will

peak at or near the middle of the range, regardless of the particular ratio forming the midpoint of the range and regardless of the ratios forming the extremes of the range. If the golden section happens to be near the midpoint, it will for that reason be one of the more preferred ratios, on the average. If it is in the periphery of the range, near one of the extreme ratios, then it will, on the average, be one of the less preferred ratios.

Berlyne's (1970) finding that "Western subjects tend to prefer rectangles tht diverge somewhat, but not very markedly, from the square, (that is, those rectangles whose longer sides are 1.3 to 1.7 times as long as the shorter sides,") was replicated by the distribution of mean preference rankings for the middle range. Also, Berlyne (1970) found the the square, one extreme of his stimulus range, evoked the largest number of first choices from both oriental and occidental subjects, not unlike the present findings for all three ranges. Berlyne's view that cultural tradition is mainly responsible for the apparent preference for the golden section is not disputed in his study. It is rather extended and qualified by the findings supporting the hypothsis that although the mean preference for the golden section and ratios may well be an artifact of the particular range of ratios prevailing in the visual displays employed and of the method of defining preference.

The results of this study are only tangential to the reliability of preferences for the golden section and related ratios found by investigators employing other than ranking methods. Some authors, using a do-it-yourself method whereby the subject has to divide a line at the point where the resultant line segments form the most pleasing ratio, find the golden section to be most preferred (e.g., Pierce, 1894); while others (e.g., Angier, 1903) do not.

In conclusion, the present findings undercut the importance of the golden section in experimental aesthetics to an important extent. The basic question

whether there is or there is not, in the Western world, a reliable verbally expressed aesthetic preference for a particular ratio between length and width of rectangular shapes can probably be answered negatively.

This general conclusion seems to be a bit overstated. We will next turn to some evidence that can be cited in favor of the basic golden section hypothesis. We next turn to evidence of work done with mental patients. To study how such a construct as the golden section functions in an abnormal setting will cast a new light on how it may function with normal subjects.

The Golden Section in Abnormal Settings

It seems only logical to study the Golden Section Hypothesis with reference to abnormal as well as normal subjects. Fahgee, Pomeroy, and Miller (1982) report a study on the interpersonal judgments of schizophrenics.

It seems evident that the GS is an established phenomenon which is perhaps fundamental to perceptual and interpersonal judgments within a normal population. As such, it is a useful phenomenon for studying clinical groups, particularly schizophrenics, who are described as having interpersonal difficulties. If the GS is found with this population, then the superficial nature of their difficulty has been demonstrated, and the contention that the GS is a fundamental phenomenon is supported. Conversely, if it is not found, it suggests that the interpersonal difficulties of the schizophrenic may be more centrally based. Studying the GS in a clinical population will provide new information regarding the phenomenon per se, and of the ability of schizophrenics to make interpersonal judgments in the same way as normals. The present study was an investigation of the ability of thought-disordered (TD) and non-thought-disordered (NTD) schizophrenics to generate the GS on a person-perception task.

This study would seem to be very important with reference to the general

Golden Section Hypothesis; for, if the Golden Section were to hold without reference to the general psychological status of the subject then the data would tend to confirm the organic or natural basis of the concept itself.

It is also apparent that much of the time schizophrenics, as a group, do not act 'crazy'. On the contrary, many are reasonably sociable and are able to maintain basic activities of daily living. Too often, only the inappropriate behavior of schizophrenics is of interest and reported; attention to the inappropriate at the expense of the appropriate may well have given us a biased picture of the abilities of this group. Our group of schizophrenics was no different clinically than other groups and yet they demonstrated the ability to perform two different tasks in much the same way as normals do. This ability, and other assets of the schizophrenic, should receive as much attention as the schizophrenic's deficits have. Certainly, the data from this study suggest that schizophrenics are able to use the same regulating principles in their daily lives as do normals.

It is generally assumed that schizophrenics show impairment on tasks which are interpersonally oriented. Many studies using the repertory grid (Bannister & Salmon, 1966; McPherson & Buckley, 1970; McPherson et al., 1975) have found that schizophrenics are more disordered on tasks which involve psychological dimensions of people. Further, the introduction of affective and interpersonal aspects into the testing situation has been shown to impair the accuracy of the performance of schizophrenics.

Taken together, P/(P+N) data and the AP scores indicate that both TD and NTD schizophrenics can make interpersonal judgments using a variety of constructs, and that they can identify with and differentiate themselves from others in the same way as normal subjects do. These data also indicate that schizophrenics assign positive descriptors to objects in GS proportions, although they attribute similarities between themselves and objects less than GS

proportions. The function of the GS in this context is not well understood. It may serve to make differentiations maximally apparent, or it may serve as an ideal which allows for the processing of new information in terms of previously obtained information, thus enabling an individual to cope with a new event with a reasonable degree of facility. Whatever its' function, it is apparent that the basic ability to process interpersonal, and, to some extent, inanimate material in GS proportions has not been altered by the schizophrenic process. Further work is needed to explore the parameters of this phenomenon, to clarify how individuals process information about inanimate objects, and to determine more precisely the nature of the schizophrenics' interpersonal difficulties. If the findings about the similarity between the ability of schizophrenics and normals to make interpersonal judgments are confirmed, they will have important implications for treating the apparent deficits in schizophreincs' interpersonal ability by building on their underlying tendency to perceive and identify with others in much the same way as normals do.

We will conclude this review of studies on the Golden Section in the area of interpersonal judgment with the work of Rigdon and Eptimz (1982). The results of their study support the extension of the golden section hypothesis to dichotomous judgments made with elicited constructs for which evaluatively positive and negative poles can be identified. The overall proportion of positive descriptions of personal acquaintances was equal to the predicted value of .618. If one accepts Kelly's (1955) assumption that personal dimensions of meaning are essentially dichotomous, the results support the idea that people generally view most of their personal acquaintances and other events as positive when they use their own personal constructs to understand these acquaintances and events. At least among college students, a slightly unbalanced use of evaluatively positive and negative constructs seems to be the norm. (Rigdon, 1982, pp. 1085)

The greater usefulness of the golden section constructs further suggests that

future research might profitably investigate a more general implication of the golden section for construct systems as a whole, rather than for the individual. According to the golden section hypothesis, individuals with extremely lopsided systems would receive little information from negative events in the environment, and this would result in a Pollyanna-like denial of the negative features of reality. Individuals with balanced or negatively lopsided systems would not have a background of generally positive events within which to interpret the negative and would, perhaps, be less capable of coping with negative events; this would result in a negativistic or depressed outlook on life. On the other hand, people who view most of the events of their life (approximately 62%) as positive will more effectively discriminate between positive and negative events in their life and be prepared to cope with negative events. If supported, this implication of the golden section hypothesis would lead to a relatively simple index of effective functioning. (Rigdon, 1982, pp. 1086)

Conclusion

Since so any of the studies which constitute the review of the literature in this paper come from work done in Psychological laboratories that were inspired in one way or another by the work of Daniel Berlyne, I wish to conclude with the work of Pluy (1980) from South Africa.

Pluy opens his article with the following observations:

"Despite its long history, the golden section hypothesis in experimental aesthetics is today as controversial as ever. Although the problem has been briefly reviewed at various times (Woodworth, 1938; Zusne, 1970; Berlyne, 1971) the more recent literature relating to the hypothesis consists mainly of isolated attempts to clarify a particular point. It therefore seems appropriate to consider the problem again in order to draw attention to the more significant previous investigations, to attempt some clarification and report some additional results. My description of the current experiment (p. 478) will be preceded by a review of previous investigations."

Considering the results obtained by the various methods discussed so far, it would appear that the following tentative conclusions are warranted:

1. Preferences for certain ratios between the dimensions of two dimensional figures or in the division of a single line differ considerably between individuals and even for the same individual at various times or under different circumstances.

2. Despite these differences, model preference for groups of subjects often falls in the 1.5 to 2.0 range of ratios, and this effect cannot at present by wholly explained by methodological factors.

3. The investigation of such preferences by presenting subjects with a limited range of fixed stimulus ratios is not likely to lead to meaningful results, while the use of some production method seems more appropriate.

A review of the literature led to the conclusion that there is a broad range of maximum preference for L/B ratios in the vicinity of the golden section. The drawings of most-pleasing ellipses by 515 subjects as reported above confirm that these preferences do exist and are only sightly influenced by the orientation of the figures or by methodological factos. It was also concluded from the literature that the preference maximum is the result of many interacting factors, so that it is likely to be of little psychological or aesthetic significance. The drawings of most-pleasing ellipses discussed above support this conclusion. It is clear that similar "preferences" can be shown to exist for the length or area of a figure. It would seem that the psychological and aesthetic relevance of such preferences is equally small in all cases and that the golden section hypothesis should die a natural death.

I believe that if there is one thing we can be sure of, is that it won't do as Pluy feels it should. The history of the Golden Section is one of those construct which, as we have been able to show in this paper has been around for a very long time and will not fade away.

It may be of some interest to observe that when a theory has so long a history, it will find those defenders as well as detractors who will maintain their basic beliefs in spite of the evidence presented. We have shown in this paper that

evidence both for and against the golden section hypothesis can be presented. The last word has not been said!

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Table 1.

Analysis of Golden Section Studies

Author(s)	Range of ratios between longer and shorter side	Position of the golden section in the range: Number of rectangles more closely approximating the square	Position of the golden section in the range: Number of rectangles more elongated than the golden section	Highest mean preference
Fechner (1876)	1.00 - 2.50	6	3	Golden section
Haines and Davies (1904)	1.07 - 3.20 1.07 - 3.60 1.05 - 4.00 1.09 - 4.80	10 13 7 9	10 10 8 10	middle four rectangles; not the golden section
Lalo (1908)	1.00 - 2.50	6	3	golden section
Thorndike (1917)	1.32 - 3.77	3	3	middle of range; not the golden section
Weber (1931)	1.00 - 2.24	3	5	around middle of range; not the golden section
Thompson (1946)	1.33 - 4.00	3	9	around middle of range; not the golden section
Eysenck and Tunstall (1968)	1.00 - 4.00	6	7	middle of range; not the golden section
Berlyne (1970)	1.00 - 2.50	6	3	middle of range; not the golden section
Total		**72**	**77**	